* NOTICES * [JP,10-163555,A]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical output compensating circuit which keeps especially the output of laser constant about the actuation circuit of the semiconductor laser used for the optical transmitter in the optical transmission system which uses an optical fiber as a transmission medium etc.
[0002]
[Description of the Prior Art] Conventionally, the approach of impressing the direct-current bias current Ib of the value near [which starts laser oscillation] the threshold current Ith as the actuation approach of the semiconductor laser (hereafter referred to as LD) module which used semiconductor laser, and carrying out pulse modulation current Ip superposition as a signal component further is common. Here, the threshold current Ith changes with ambient temperature. For this reason, when LD is driven with a fixed current, fluctuation arises [optical output level] with an ambient temperature. Moreover, the differential effectiveness eta which is the effectiveness which changes an electrical signal into a lightwave signal by degradation of LD gets worse, and optical output level and an extinction ratio get worse.
[0003] For this reason, JP,7-147446,A, JP,4-82285,A (it is hereafter called the conventional techniques 1 and 2, respectively), etc. are already proposed as an approach for keeping an optical output constant.
[0004] Drawing 7 is the block diagram showing the configuration of the actuation circuit of the optical-fiber module by the conventional technique 1. As shown in drawing 7 , it has the photo detector 52 which detects the optical output of LD51, the pulse current modulation circuit 53 which supplies pulse current to LD51, the pulse current control circuit 54 which controls the pulse current value of the pulse current modulation circuit 53, the power monitor circuit 55 which detects the detection output of a photo detector, and the bias current control circuit 56 which controls the bias current Ib which emits light in LD51.
[0005] It computes a threshold current by it changing two or more bias current Ib for every fixed time amount, if LD actuation circuit proposed here is summarized, and detecting the luminescence power of LD51 in that case with a light-receiving power detection means, and sets the direct-current bias current Ib of LD [a little]51 higher than a threshold current as the bias current control circuit 54.

[0006] Moreover, optical output level is uniformly held by setting it as the pulse current corresponding to change of the differential effectiveness eta etc. by detecting change of the threshold current of LD51, and the differential effectiveness eta in the pulse current control circuit 54.
[0007] Next, the conventional technique 2 is explained. Drawing 8 is drawing showing the optical output compensating circuit proposed by the conventional technique 2. As shown in drawing 8 , an optical output compensating circuit performs feedback control, respectively about the dc component of a monitor signal and signal component (pulse component) which were extracted from the output lightwave signal of LD, and all compensates it with the average light power of an output lightwave signal, and an extinction ratio. Specifically, the monitor signal outputted from the photo detector 61 for monitors (PD) is inputted into an amplifying circuit 62, an integrating circuit 63, and the peak hold circuit 64. Here, an integrating circuit 63 extracts the average of an output lightwave signal from a monitor signal. On the other hand, it is combined with the photo detector 61 for monitors in alternating current, and a peak hold circuit extracts the signal amplitude of a monitor signal. Therefore, negative feedback is applied to the actuation current of the laser diode actuation circuit 65 through a subtractor circuit 66 and comparators 67 and 68, and it is made to stabilize the signal amplitude of an output lightwave signal so that signal amplitude which the peak hold circuit 64 extracted may be made regularity.
[0008]
[Problem(s) to be Solved by the Invention] In the Prior art, since the extinction ratio also got worse and the difference with the time of "1" level-signal transmission and "0" level-signal transmission became small when becoming irregular with the fixed pulse modulation current Ip, and the differential effectiveness of LD got worse, when degradation of LD arose according to temperature fluctuation or secular change, it was a problem that the extinction ratio of LD gets worse and the dependability of data communication falls. That is, it is that an error rate rises. Here, an extinction ratio is a ratio of two sorts of optical reinforcement corresponding to each of a binary signal.
[0009] Moreover, in order to avoid the above-mentioned trouble, in the conventional technique 1, it is necessary to change two or more bias current Ib for every fixed time amount, to detect change of a threshold current and differential effectiveness, and to control a threshold current and the pulse modulation current Ip. Because, there is rapid degradation by external factors, such as the late defect of degradation and a light emitting device or late overcurrent by the laser oscillation of long duration, and elevated-temperature energization, as degradation mode of LD. When the pulse modulation current Ip was controlled only by fixed time amount, such as at the time [At the time of ON of a power source] of fixed period and system error generating etc., and degradation of LD progresses quickly, it is because it becomes impossible to hold an extinction ratio uniformly.
[0010] Moreover, with the conventional technique 2, in order to avoid the above-mentioned trouble, the negative feedback circuit has realized stability of an extinction ratio. However, the good photo detector of the large amplifier of a frequency band and high-speed responsibility was needed, and the feedback circuit became complicated [a circuit], and it had the fault that a hard amount increased.

[0011] Then, 1 technical technical problem of this invention is to offer the optical output level control approach which can maintain an extinction ratio fixed even when differential effectiveness changes with degradation of LD by supervising the difference of the monitor output of two kinds of stimuli with which duty (duty) ratios differ, and controlling the pulse modulation current Ip, and a control unit.

[0012] Moreover, another technical technical problem of this invention is by always supervising change of bias current Ib to offer the optical output level control approach which can respond also to degradation of rapid LD, and a control unit.

[0013]

[Means for Solving the Problem] In the actuation approach of the laser diode (hereafter referred to as LD) of a method of making the pulse modulation current Ip superimposing on bias current Ib according to this invention The monitor of the optical output of said LD is carried out using the 1st and 2nd stimuli with which duty (duty) ratios differ mutually, the average of a monitor output signal is detected, and the average is memorized. The difference of the average of said 1st and 2nd stimuli, The optical output level control approach characterized by controlling the pulse modulation current Ip according to the difference concerned is acquired taking the difference of the monitor output average value in the initial state of said LD, and the monitor output average value after LD oscillation, and supervising change of said bias current Ib.

[0014] Moreover, when according to this invention change of said bias current Ib is supervised with time and change of said bias current Ib is advancing in said optical output level control approach for a short time, the optical output level control approach characterized by outputting LD degradation proceed signal is acquired.

[0015] Moreover, according to this invention, it sets in the actuation circuit of the laser diode (hereafter referred to as LD) of the method which makes the pulse modulation current Ip superimpose on bias current Ib. The photo detector for monitors for a duty (duty) ratio to carry out the monitor of the optical output of said LD using the 1st and 2nd mutually different stimuli, The average detector which detects the average of the monitor output signal of said photo detector for monitors, The output of said average detector is memorized. The difference of the average of said 1st and 2nd stimuli, the storage which takes the difference of the monitor output average in the initial state of LD, and the monitor output average after LD oscillation -- difference -- with an arithmetic circuit the bias current supervisory circuit which supervises change of said bias current Ib, and said storage -- difference -- the optical output level control equipment characterized by having the pulse modulation control circuit which controls a pulse modulation current according to the output of an arithmetic circuit is obtained.

[0016] Furthermore, when according to this invention a timer circuit is prepared in said optical output level control equipment in the bias current supervisory circuit which supervises change of said bias current Ib and change of said bias current Ib is advancing for a short time, the optical output level control equipment characterized by outputting LD degradation proceed signal is obtained.

[0017]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.

[0018] (Gestalt of the 1st operation) Drawing 1 is the block diagram showing the configuration of the optical output level control equipment by the gestalt of operation of

the 1st of this invention. As shown in drawing 1 , optical output level control equipment is equipped with LD actuation circuit 1 and the LD module 2.

[0019] LD actuation circuit 1 -- the mode selection circuit 3, the average-value detector 4, and storage -- difference -- it has an arithmetic circuit 5, the pulse modulation control circuit 6, the bias control circuit 7, the electronic switch 8, the bias circuit 9, the bias current supervisory circuit 10, and the pulse modulation circuit 11. Moreover, the LD module 2 is equipped with the photo detector 13 for monitors for [of the LD component 12 and the LD component 12] carrying out an optical output monitor in it.

[0020] In LD actuation circuit 1, the mode selection circuit 3 is a circuit which sets up LD actuation circuit 1 for any of the test mode which controls the extinction ratio of normal operation mode or LD being. The average-value detector 4 is a circuit which detects the average optical output of the LD component 12 by the monitor output of the photo detector 13 for monitors of two kinds of stimuli with which duty (duty) ratios differ, i.e., the 1st and 2nd stimuli.

[0021] storage -- difference -- an arithmetic circuit 5 is a circuit which memorizes the output of the average detector 4 of the 1st and 2nd stimuli with which the duty (duty) ratios in an initial state differ, and takes the difference. moreover, storage -- difference -- in an arithmetic circuit 5, difference with the average optical output of the stimulus after the average optical output of the stimulus in an initial state and degradation of LD progress is also taken.

[0022] the pulse modulation control circuit 6 -- storage -- difference -- the difference of an arithmetic circuit 5 -- when a result is changed to initial value, it is the circuit which controls the pulse modulation current Ip.

[0023] The bias control circuit 7 is a circuit which controls the value of bias current Ib so that the average value of an optical output becomes fixed based on the output of the average-value detector 4.

[0024] an electronic switch 8 -- the output of the average-value detector 4 -- the bias control circuit 7 or storage -- difference -- it is the circuit changed to either of the arithmetic circuits 5 according to setting out of the mode selection circuit 3. A bias circuit 9 is a circuit which passes bias current Ib for the LD component 12.

[0025] Moreover, the bias current supervisory circuit 10 is a circuit which outputs a degradation signal to a high order circuit, when the variation of bias current Ib is supervised and fluctuation arises.

[0026] Furthermore, the pulse modulation circuit 11 is a circuit which carries out pulse actuation of the LD component 12 by making bias current Ib superimpose the pulse modulation current Ip on the LD component 12, and passing.

[0027] Before beginning introduction and the usual data transfer, in the initial state of LD, LD actuation circuit 1 is set as test mode with the mode change signal from a high order circuit. In test mode, the stimulus (the 1st and 2nd stimuli) with which two kinds of duty (duty) ratios differ is inputted into LD actuation circuit 1 as transmit data from a high order circuit. Stimulus A is a signal of the duty (duty) ratio 6 to 4, and Stimulus B is a signal of the duty ratio 4 to 6.

[0028] Actuation of the optical output level control equipment by the gestalt of operation of the 1st of this invention is explained.

[0029] Before starting normal operation, the mode selection circuit 3 is set as test mode from a high order circuit. In test mode, two kinds of stimuli A and B with which duty

(duty) ratios differ as transmit data are outputted from a high order circuit. the output of the photo detector 13 for monitors in that case -- storage -- difference -- it inputs into an arithmetic circuit 5. Since duty (duty) ratios differ, optical output RE ** RU of LD12 differs, and, as for Stimuli A and B, monitor outputs also differ. storage -- difference -- an arithmetic circuit 5 -- monitor output PA PB Difference deltaP=PA-PB It takes and the result is memorized. When LD12 carries out a long duration oscillation, degradation progresses and the inclination (differential effectiveness eta) of an optical output-bias current characteristic gets worse. For this reason, an extinction ratio gets worse only by control of bias current Ib. the property in which degradation of LD advances gradually in order to prevent this -- using -- several months -- about 1 time -- periodical -- a stimulus -- transmitting -- difference -- taking -- the value -- storage -- difference -- when it changes to the initial value memorized in the arithmetic circuit 5, the pulse modulation current Ip is controlled by the pulse modulation control circuit 6, and an extinction ratio is kept constant.

[0030] namely, storage -- difference -- since the differential effectiveness eta is getting worse when the difference in an arithmetic circuit 5 becomes smaller than initial value, the pulse modulation current Ip is made to increase Conversely, when the difference is large, the pulse modulation current Ip is decreased. By controlling the pulse modulation current Ip, even if the differential effectiveness eta gets worse, an extinction ratio can be kept constant.

[0031] Moreover, change of bias current Ib is always supervised in a bias current supervisory circuit, when bias current Ib increases substantially, it judges that degradation of LD12 progressed quickly, and pulse current Ip is controlled similarly.

[0032] Next, drawing 2 thru/or drawing 4 are further used for drawing 1 , and the optical output level control equipment by the gestalt of operation of the 1st of this invention is concretely explained to it.

[0033] Drawing 2 is a graph which shows the optical output-current characteristic in the initial state of general LD. As shown in drawing 2 , when carrying out pulse actuation of the LD generally, bias current Ib is somewhat set as a large value from the threshold current Ith, and the pulse modulation current Ip is superimposed there.

[0034] The stimulus inputted into LD actuation circuit 1 carries out pulse luminescence by outputting the pulse modulation current Ip and flowing for the LD component 12, as the pulse modulation circuit 12 shows to drawing 2 . The monitor of the optical output of the LD component 12 in this case is carried out by the photo detector 13 for monitors, and it outputs to the average detector 4.

[0035] The average of an optical output is detected in the average detector 4. the optical output average (PA1) of Stimulus A, and the optical output average of Stimulus B -- (PB2) -- respectively -- storage -- difference -- it outputs to an arithmetic circuit 5. Since, as for Stimulus A and Stimulus B, duty (duty) ratios differ, optical output level also differs. Among the outputs PA1 and PB1 of the average detector 4, the relation shown by the following several 1 formulas is realized.

[0036]

[Equation 1]

storage -- difference -- in an arithmetic circuit 5, the difference (deltaP11) of PA1 and PA2 is calculated, and the value is memorized. Difference is expressed with the several 2 following formulas.
[0037]
[Equation 2]

The differential effectiveness eta which is the effectiveness which changes an electrical signal into a lightwave signal is expressed with the inclination of the graph of an optical output-current characteristic as shown in the several 3 following formulas.
[0038]
[Equation 3]

in the above, it explained -- as -- the optical output averages PA1 and PB2 of the stimuli A and B in the initial state of LD -- the average detector 4 -- detecting -- the difference deltaP11 -- storage -- difference -- after memorizing in an arithmetic circuit 5, the mode selection circuit 3 is set as the normal mode, and normal operation is started.
[0039] It is the same as that of the automatic optical output control circuit (APC) method by the average optical output detection conventional in the normal operation condition here, and the output of the average-value detector 4 is inputted into the bias control circuit 7 in an electronic switch 8. Bias current Ib is controlled by the bias control circuit 7 so that the inside of normal operation also always becomes fixed [the average value of monitor Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne.] about an optical output. However, the pulse modulation current Ip is fixed with initial value.
[0040] Moreover, there are two kinds, degradation late as degradation mode of LD and rapid degradation. The late former degradation is degradation which progresses by carrying out long duration laser oscillation by the normal operating state. On the other hand, the latter rapid degradation is degradation which progresses rapidly according to external factors, such as a defect of a light emitting device and an overcurrent, and elevated-temperature energization. If degradation of LD progresses, the differential effectiveness eta will change. This situation is shown in drawing 3 .
[0041] With the same pulse modulation current Ip as the initial state shown in drawing 2 , the differential effectiveness eta becomes like the following several 4 formulas and several 5 formulas.
[0042]
[Equation 4]

[0043]
[Equation 5]

As shown in the number 4 above-mentioned formula and several 5 formulas, only by control of conventional bias current Ib, an extinction ratio gets worse and the dependability of data transfer falls.

[0044] the gestalt of operation of the 1st of this invention in order to prevent this -- setting -- being periodical (it being about 1 time in several months) -- LD actuation circuit 1 -- test mode -- setting up -- a high order circuit -- a stimulus -- transmitting -- the difference of the average optical output in that case -- taking -- storage -- difference -- to the initial value memorized to the arithmetic circuit 5, when fluctuation arises, pulse current Ip is controlled by the pulse modulation control circuit 6, and an extinction ratio is set constant.
[0045] the time of an initial state -- the same -- the difference between the output PA 2 of the average detector 6 at the time of stimulus A transmission, and the output PB2 of the average detector at the time of stimulus B transmission -- storage -- difference -- it takes in an arithmetic circuit 5 and difference with the value deltaP11 in an initial state is taken further. Since the differential effectiveness eta is getting worse, it becomes like the several 6 following formulas and several 7 formulas.

[0046]
[Equation 6]

[0047]
[Equation 7]

Since it changed to deltaP11>deltaP22 and initial value, the pulse modulation current Ip is made to increase in the pulse modulation control circuit 6, so that this may become fixed.
[0048] After the above actuation is completed, it is set as normal operation mode. Control of the pulse modulation current Ip is not performed only by controlling the bias current Ib by optical output average-value detection in normal operation mode. Thereby, optical output level and an extinction ratio can be held uniformly. This situation is shown in drawing 4.
[0049] As shown in drawing 4 , the differential effectiveness eta is eta1 >eta2. Since it has become, the pulse modulation current Ip is set to Ip2, and it is made to increase.
[0050] Moreover, when degradation progresses quickly, since the threshold current Ith increases substantially, bias current Ib also increases. When change of bias current Ib is supervised in the bias current supervisory circuit 10 and bias current Ib increases to initial value (for example, 1.3 times), it is judged as that in which LD deteriorated quickly, and LD degradation signal is outputted to a high order circuit. As LD actuation circuit 1 is set as test mode and mentioned above in response to this signal, a high order circuit controls the pulse modulation current Ip, and keeps an extinction ratio constant corresponding to rapid degradation of LD.
[0051] Moreover, when bias current Ib exceeds twice to initial value, it judges that LD is poor and a defect signal is outputted to high order equipment.
[0052] As explained above, also when degradation of LD progresses gradually under supervising the MONI evening output of two kinds of stimuli with which duty (duty) ratios differ, and also when it progresses quickly, with the gestalt of operation of the 1st of this invention, an extinction ratio can be held uniformly.

[0053] (Gestalt of the 2nd operation) Next, the gestalt of operation of the 2nd of this invention is explained.
[0054] Drawing 5 is the block diagram showing the configuration of the optical output level control equipment by the gestalt of operation of the 2nd of this invention. Although test mode and normal operation mode are changed by the mode selection circuit 3 and the electronic switch 8 with the gestalt of the 1st operation as shown in drawing 5 , the gestalt of the 2nd operation at the point of having removed the mode selection circuit 3 and the electronic switch 8 differs from the gestalt of the 1st operation with the gestalt of the 2nd operation.
[0055] In the optical output level control equipment by the gestalt of the 2nd operation, when controlling an extinction ratio like the gestalt of implementation of the 1st operation, a mode change signal and Stimuli A and B are inputted into LD actuation circuit 1 from high order equipment. a mode change signal -- storage -- difference -- it is used as an enable signal of an arithmetic circuit 9 and the pulse modulation control circuit 12. a mode change signal -- enabling -- {-- for example, -- yes, when it is (HI) level}, Stimuli A and B transmit -- having -- storage -- difference -- like the case of the gestalt of the 1st operation, an arithmetic circuit 5 takes the difference between two kinds of stimuli, and when there is fluctuation to initial value, it controls the pulse modulation current Ip by the pulse modulation control circuit 6.
[0056] a normal operating state -- a mode change signal -- low (LO) level -- it is -- storage -- difference -- an arithmetic circuit 5 and the pulse modulation control circuit 6 do not operate, but perform only control of bias current Ib.
[0057] In the gestalt of the 2nd operation, although the duty (duty) ratio is using the signal of 6 to 4 and 4 to 6 as a stimulus, if, as for this, a difference appears in the average value of the output of the photo detector 13 for monitors between two-kind stimuli, any number of duty (duty) ratios are good.
[0058] (Gestalt of the 3rd operation) Next, the gestalt of operation of the 3rd of this invention is explained. drawing 6 is drawing boiling and showing the configuration of the optical output level control equipment by the gestalt of operation of the 3rd of this invention. As shown in drawing 6 , what is depended on the gestalt of operation of the 3rd of this invention has the same configuration as what a timer circuit 14 is built in the bias current supervisory circuit 10, and also is depended on the gestalt of the 2nd operation. This timer circuit 14 measures the time amount from which bias current changes.
[0059] When degradation progresses, the threshold current Ith increases and it becomes impossible here, for optical output level to fall and use LD eventually. However, since it notifies that output a degradation proceed signal to high order equipment, and degradation of LD is progressing quickly when the increment in bias current Ib is advancing for a short time by forming a timer circuit 14 in the bias current supervisory circuit 10, degradation can be known in advance and the cure can be performed a little early.
[0060]
[Effect of the Invention] As mentioned above, according to this invention, as explained, the difference of the monitor output of the 1st and 2nd stimuli with which duty (duty) ratios differ is supervised, and in order to control the pulse modulation current Ip so that an extinction ratio becomes fixed, even when the property of LD gets worse according to

temperature fluctuation, secular change, etc., the optical output level control approach and equipment which can hold an extinction ratio to a fixed value can be offered.

[0061] Moreover, since according to this invention it is set as the test mode which outputs a degradation signal and controls the pulse modulation current Ip when change of bias current Ib is supervised in a bias current supervisory circuit and bias current Ib is changed to initial value, also when degradation of LD progresses quickly, the optical output level control approach and equipment which control the value of the pulse modulation current Ip and can hold an extinction ratio uniformly can be offered.

[0062] Moreover, since according to this invention a degradation proceed signal is outputted to a high order circuit when the time amount from which bias current Ib changes by preparing a timer circuit further is measured to a bias current supervisory circuit and bias current Ib is increasing to it for a short time, the optical output level control approach and equipment which can grasp in advance that degradation of LD is advancing quickly can be offered.

[0063] Moreover, in order not to perform peak value detection of the optical output by the feedback circuit, in order that there may not be a high-speed photo detector and the need for amplifier according to this invention, circuitry becomes simple rather than what is depended on the conventional technique (for example, the conventional technique 2), and the optical output level control approach and equipment which can use general-purpose components can be offered.

[Translation done.]